is a very grim joke, but we must bear with it and many others of the same kind, and in the meantime we do say that we agree with Dr. Lodge in his notion that our true and only natural foes are ignorance and prejudice. This ignorance of the needs of mere mechanical persons and prejudice against attempts to teach them, are fashionable now among scientific men. At the recent dinner of the Royal Society quite a genteel titter greeted a casual reference to technical education in one of the speeches.

I like algebra myself, but I do not think that it is the only possible conventional way of making an exact statement. However, taking Dr. Lodge's student with his "true from the bottom upwards and entirely true," mariner's formula to find a certain academic distance; is it quite certain that he will think of using it in a practical case? In my experience it is the very last thing that will enter his mind. I should not call him an ass, as Dr. Lodge does; he only follows Plato's maxim, not altogether neglected in English education, that philosophy ought to serve no useful purpose. The Wrangler's naïve faith, when he does condescend to a practical problem, is generally shocked in finding that such problems require the addition of a little common sense to the formula. Now I do not object to a man's finding out the usefulness of a rule (call it a mere numerical rule if you like, but it is evidently a very different thing), in actual practical examples before he understands how it is derived, for I am confident that he will then be easily induced to inquire how the rule is arrived at; he will go further and think of the evidence for the roundness of the earth, and indeed it may prove to be the starting-point in his scientific education. I grant you that he will not go far if his instructor makes him begin his studies with the six books of Euclid. Why does the mariner remain so ignorant of mathematics although he uses the results every day? Surely he wants to know the why? Yes, indeed he does, but you have taught him that he cannot know the why unless after years of quasi-philosophic worry.

When I spoke of the practical knowledge needed by the engineer, I meant to include such knowledge of physics as is possessed by Dr. Lodge himself; I mean no mere pocket-book knowledge. Before a student can get to this higher region he needs to be taught to think, and it is in our notions of this preliminary training that I differ from Dr. Lodge.

I do not care much what a man's system of teaching may be; if it is his own, however faddy, he will teach his students better than on a better system, not his own. But we must acknowledge that the average teacher needs a system to be given to him, and this ought to be the best system. Well, I think that the existing system is about the very worst possible. We compel a student to boggle at imaginary difficulties. We worry him for years over four books of Euclid; we have given up the fifth book, and even the supplement to the fifth, but we still worry him with the sixth, and then go on to geometrical conics. Now even the sixth book merely involves ideas which every boy takes in without much difficulty; it is so natural to think of using any unit of length, that Dr. Lodge forgets how the ideas of the sixth book are needed in his simple mariner's rule. But as soon as a student begins his work in physics, he is rushed over difficulties to which the difficulty of thinking about the mere ratio of lines is nothing. I do not say that he ought not to be suddenly surrounded with ideas of the sums and differences and ratios of all sorts of scalar and vector conventions for quantities, and told to sink or swim among them. I think this the very best thing for him; but what of your consistency in mind-training, of the philosophy of your methods? Dr. Lodge compels me to describe my non-academic way of teaching. I thought that everybody knew it, but evidently he does not.

I believe in using the experimental method from the beginning; of squares and ratios of sides of all sorts of right-angled triangles being figured out by the boy of eight years of age, to see how near he gets to tabulated sines and cosines. I believe in his measuring time and lines and forces with the watches and scales and balances which are in common use; in testing the rules of mensuration of areas and volumes, and the finding of weights of bodies by calculation; and it is only when a boy has a good quantitative knowledge from his own experience that I trouble him with the philosophy of mathematics and physics, and then I do it cautiously. I make beginners plot curves on squared paper—curves showing the rate of increase in the price of silk or cotton or the height of the barometer, or the National Debt or other things given in Whitaker's Almanac—in telling them about the slope of a curve and its analogy with velocity and acceleration and dy/dx and ds/dt and d^2s/dt^2. They "graph" all sorts of curves; they add and subtract vectors by actual drawing, and their lectures and laboratory work and graphical and numerical exercise work go on simultaneously.

Some of my academic friends not only refuse to let a student use a formula, but they refuse to let him use a table of logarithms until he can calculate logarithms. To be consistent they ought to refuse the use of a watch or of clothes until a student has shown aptitude in the watchmaking and tailoring trades. I let my students use any appliance whatsoever if I think that it will give them a better acquaintance with natural phenomena; anything that will cause them to think. As a student gets on I let him take all sorts of liberties in regard to units; he uses w/g for m; he speaks of centre of gravity instead of centre of mass or centre of area.

Also, I venture to tell Dr. Lodge that the very best of my students, who know something of Bessel functions and spherical harmonics and elementary St. Venant work on the torsion and bending of prisms, and something about generalised coordinates, are taught to have the very highest respect for the rule-of-thumb practical methods of calculation in use among engineers. They are taught that the engineer has to deal with things that are by no means so simple as the ordinary laboratory phenomena, and that rules arrived at through the trials and errors of generations of practical men are worthy of some respect.

Lastly, I may say that we are tired of the whole academic system which recognises no philosophy or literature or art which is not studied as a dull grind for examination purposes, and I am thankful to say that we have indeed "a sympathetic faith in a much larger training."

JOHN PERRY.

December 17.

The Earthquake of December 17.

IT may interest your readers to know that the recent earthquake of December 17 was shown slightly on the declination curve, and more distinctly on the horizontal force curve, at Kew Observatory. The time of commencement was 5h. 35m. a.m. (± 1 minute) G.M.T. The disturbance on the horizontal force trace approximately equalled what would have been produced by a change of 0·00004 C.G.S. units in that force.

CHARLES CHREE.

Kew Observatory, Richmond, Surrey, December 19.

EARTHQUAKE shocks occurred in Worcester at 3.35 and at 5.31 a.m. on Thursday. The 3.35 shock was feeble, of short duration, and was noticed but by few persons. But the visitation of 5.31 exceeded in violence any previous instance of seismic energy here within the present century. There were in the 5.31 instance two shocks following each other with a bare interval. The shocks consisted of a series of rapid vibrations, too rapid to admit of count. These shocks were preceded by a roar as of thunder. Some describe the roar as that of the noise of a "rushing mighty wind." My house was shaken with appalling violence, displacing roof tiles, and forcing open a closed chamber door. To me the shocks seemed to proceed from north to south. The duration of the shocks lasted between four and five seconds. Some say the shocks lasted fifteen seconds; but if the earthquake had lasted so long, my house would have been down. As it was the house was rocked to its foundation, and the sensation was appalling. Persons whose bedrooms faced the north, saw a great light accompanying the earthquake. This peculiarity is by some attributed to lightning, by others to the effect of a large meteor. Mr. Russell Dirrell, of North Piddle, a place seven miles east of Worcester, saw at the time of the earthquake a great blaze of light low in the northern horizon, continuing for two or three seconds. He was unable to attribute the blaze to a lightning effect. At the homestead of Mr. Walters, of Hallow, three miles north of Worcester, the inmates were thrown out of bed, as was the case in several other instances in the same village. Here the shocks were most severely felt at places on the west of the Severn. In Worcester the shocks created general alarm. Bells were set ringing, shut doors forced open, windows rattled, heavy wardrobes displaced, earthenware scattered about, in some instances broken, but no one was injured. A strong fixed wash-hand basin in a lavatory was split to pieces. The church clock of All Saints, on the east of the Severn, was stopped at 5.15 a.m. As seems to be usual in such cases, poultry and pheasants flew down from their perches and showed signs of distress, birds flew aimlessly about and

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clamoured. Graziers noticed that their milch cows were greatly trembling and seemed dazed, and horses ran about the pastures. During the shocks the river Severn here suddenly surged and angrily foamed up to the level of its banks, subsiding to its former level on the cessation of the 5.31 shocks. At Hallow, a labourer stooping to lace his boots was pitched headlong into the fire.

The season here has been marked throughout by exceptionally low readings of the barometer, such as 28, 50, 28, 70, and 29. The thermometer in my bedroom at 5.31 on the 17th was 38. The direction of the wind was northerly.

Worcester, December 19. J. Lloyd Bozward.

(1) The only record that I have seen here, undisturbed as yet, of the measurable displacement of any object by the shock, is that of a large iron ornamental vase on pedestal, weighing at least 100 kilos., standing in the middle of a lawn on a stone foundation sunk in the ground. This has been moved sideways on its foundation through a space of 3 cm. I laid a long straight lath close to it in the approximate direction of displacement, and took compass readings near each end of the lath (to eliminate any deflexion due to the mass of iron). The mean of the readings gives magnetic N. 18° 30′ E., as the direction of displacement of the mass. The true direction may, however, have been rather nearer to magnetic N., for the pedestal is square and slightly sunk below the surface; and as the sides were forced obliquely against the turf, the motion may have been deflected from the line which would have been taken if there had been no resistance.

(2) One piece of evidence that the plane of the oscillation here was mainly, at any rate, horizontal, may be worth giving. I have a barograph (Richard Frères pattern) screwed firmly to a bracket attached to one of the internal walls of the house. The long recording arm of this is so sensitive to changes of vertical pressure, that the mere employment of a housemaid's brush near the instrument is enough to cause a vertical displacement of 1–2 mm. in the ink-trace; and, contrary to instincts of tidiness, I have had to give a caution against dusting operations in the neighbourhood, so many "dust-storms" have been graphically registered.

If, then, there was any vertical movement in the wall during the shock, there would undoubtedly be a straight vertical line on the ink-trace. If the movement was purely horizontal, the pen would simply be jerked away from the paper, and would fall back to its former position.

I examined the register shortly after the shock, and could find no trace whatever of any vertical irregularity in the barometric trace. The air-pressure, I may also mention, was remarkably uniform during many hours preceding and following the shock.

(3) Lastly I would note, as an evidence of weakness and probable strain in the strata of this district, the extensive line of fault (or rather two parallel adjacent faults) which runs nearly N.N.E. and S.S.W. through Newent, between the Malvern Range and Hereford, where the shock seems to have been most severe. On the west side of these faults, we have on the surface the Old Red Sandstone; on the east side, the Keuper Marls, the Old Red having been thrown down at least 4000 feet.

Gloucester, December 19. E. R. P.

THE EARTHQUAKE.

Until last Thursday, the great Essex earthquake of 1884 held the premier place among British earthquakes of the last few centuries. So far as structural damage is concerned it is not yet displaced from that position, for, though in many places chimneys were thrown down by Thursday's disturbance (at Hereford at least one of the pinnacles of the Cathedral was damaged), yet there does not appear to have been that wholesale destruction which marked the Essex earthquake at Colchester and the surrounding villages. With regard to disturbed area, however, the inequality is reversed.[1] Though the recent shock occurred at a time (5.32 a.m.) when many observers were asleep, there can be little doubt that it was practically felt over the whole of England and Wales. At present we have only to exclude the terminal counties of Northumberland, Norfolk, Suffolk, Kent and Cornwall; and possibly these exceptions will disappear when fuller details are obtained. So far, no record has come from Ireland, but there can be little doubt that it must have been felt along the east coast, if not for some distance inland.

With regard to my own observations, I was roused at 5h. 32½m. from a dream of earthquakes, by a series of fairly strong regular vibrations of approximately equal intensity. Those I felt obviously belonged to the second half of the shock; they were eight in number, occupied exactly three seconds, and were of equal period, except that between the fourth and fifth the interval was half as long again as between the others. The motion was distinctly lateral, from a nearly westerly direction, the return movement being less perceptible than the forward, so that the shock appeared to consist of a series of firm powerful shoves. No sound was heard during these last three seconds, though I awoke with a feeling that the noise had just ceased; and this fact led me at once to assign a somewhat distant origin to the shock, possibly somewhere in Wales. As telegrams gradually arrived from various parts, it became evident that the epicentre must lie to the south-west, at some fifty miles from Birmingham.

The area within which buildings were damaged, includes Hereford, Ross, Worcester, Gloucester, Dursley, Cinderford and other places, and is not less than thirty miles in length. It would be premature to make any definite statement as to the exact position of the epicentre, or to suggest any fault with which the earthquake may be connected. But when these places are plotted on a map, one cannot but be struck by the fact that the district within which they lie agrees very closely with the epicentral areas of two previous earthquakes, those of October 6, 1863,[1] and October 30, 1868.[2] The former of these was a distinctly strong shock; and even now, in making earthquake inquiries in the district, I frequently receive references to it.

As I am collecting materials for a memoir on the earthquake of Thursday, I should be glad if I might take this opportunity of appealing to all readers of Nature who can in any way help me, either by describing their own observations, or inducing others to do so. A brief list of questions having recently appeared in Nature (vol. xlvi., p. 401), it is unnecessary to reprint them here.[3] They will also, I hope, be found in many local newspapers. If those who have the opportunity would examine the records of self-registering instruments, some useful information might be obtained with regard to time of occurrence at different places. I need hardly say how interesting it would be to have photographs of buildings which have been in any way damaged by the earthquake. I should also be very grateful for any notes, however scanty, on the earthquakes of 1863 and 1868; for, if the suggested connection between them and the recent shock should prove a true one, they will in all probability furnish important evidence as to the later stages in the growth of the originating fault. C. Davison.

373 Gillott Road, Birmingham, December 19.

P.S.—Since the above was written, I have received records from places in each of the counties mentioned above as apparently undisturbed, and from one place in Ireland (co. Wicklow). C. D.

December 22.

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[1] The disturbed area of the Essex earthquake is estimated by Messrs. Meldola and White at about 50,000 square miles. This has been exceeded on two later occasions by the Pembroke earthquakes of August 18, 1892, and November 2, 1893, a paper on which will be read before the Geological Society on January 6 next.

[1] E. J. Lowe, F.R.S. "History of the Earthquake of 1863, October 6." Brit. Meteor. Soc. *Proc.*, ii., 1865, pp. 55-99.

[2] Symons's *Meteor. Mag.*, iii., 1868, pp. 153-154.

[3] See also *Knowledge* for August 1896, pp. 190-191.

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